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DEVELOPMENT OF A HIGHLY DISSIPATIVE BREAKWATER WITH VERTICAL MIXING FUNCTIONS

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ABSTRACT

In this study, an offshore facility that aims sea water mixing and diffusion along the vertical direction in a semi-enclosed bay is intended for development through the use of wave energy as a driving force. A water chamber type breakwater comprised of a row of vertical walls of different drafts and a submerged horizontal plate was proposed as a typical structure in order to be able to utilize piston mode wave resonances and resultant vortex generations for the effective vertical mixing. Especially, a wedge section of the front wall was adopted to induce the mean flow along the vertical direction of the structure as a resultant effect of asymmetrically generated vortex flows at the mouth of the water chamber. Additional function of the structure as a breakwater was also examined.

KEY WORDS: Wave dissipation, vertical mixing, semi-closed bay, piston mode wave resonance, water-chamber type breakwater

INTRODUCTION

In a semi-closed bay, water temperature stratifications usually develop during summer and the bottom layer may easily become anoxic due to impeded vertical mixing. Anoxic water promotes elution of nutrient salts and sulfides in the bottom mud and is considered in some cases to be the main cause of triggering blue tides and the explosive growth of phytoplankton (red tide). Consequently, coastal or marine facilities as one of possible counter measures are being planned and constructed to improve water quality in the semi-enclosed bay by exchanging water between inside and outside the bay using seawater exchange breakwaters and permeable breakwaters. A partly permeable seawall for generating vertical circulating flows by the use of wave overtopping was proposed by Oda et al (2001). Another possible measure is the empirical experiment for improving water quality of the bottom layer using electrically powered aeration systems, typically micro bubble aeration systems (Yamamoto et al., 2006).

The aim of this study is to develop marine facilities designed to promote vertical mixing for water quality improvement in a semi-closed bay by utilizing wave energy as a driving force. Nakamura et al (2003) have proposed a water exchange breakwater through the use of wave induced vortices at the opening mouth of a water chamber. It is comprised of two curtain walls (vertical barriers) and a submerged horizontal plate which connects to the rear curtain wall at the corner.

It was reported by Nakamura et al that the new breakwater is able to induce a significant amount of mean current through the use of piston mode wave resonance inside the water chamber and the resultant strong vortex flows. In this study, the same principle has been adopted to develop the facilities for effective vertical mixing of sea water in a semi-enclosed bay. Specifically, a wedge-shaped structure for the front wall was adopted to induce asymmetrical vortex flows which results in a mean current in the vertical direction through the rectangular slot inside the water chamber. A wave dissipating effect is expected by the wave energy loss as a consequence of the generation of strong vortex flows about the structure. This, in combination with the characteristic features of the mean current through the rectangular slot mentioned above, accounts for the wave dissipating effect.

EXPERIMENT

Experimental Apparatus

A long wave flume (30 m long, 1 m wide and 1.25 m deep) at Ehime University was used in the experiment. A 1:30 slope was set up in the wave flume and it was connected smoothly to a horizontal bed as shown in Fig.1. A partition wall was constructed on the horizontal bed longitudinally so that it divided the wave flume approximately in half. Incident waves were measured in one of divided wave channels and the other channel was used for mounting model bodies. A wave generator was located at one end of the wave flume and a wave absorber at the other end consisting of a slope of gravel with porous material underneath. The two divided wave channels joined again at the wave absorber end to minimize the influence of water level difference on the flow field about the breakwater by the generation of a mean current.

Model Breakwaters